U.S. FISH AND WILDLIFE SERVICE
SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

SCIENTIFIC NAME: *Cryptobranchus alleganiensis bishopi*

COMMON NAME: Ozark hellbender

LEAD REGION: 3

INFORMATION CURRENT AS OF: January 2006

STATUS/ACTION:

___ Species assessment - determined species did not meet the definition of endangered or threatened under the Act and, therefore, was not elevated to Candidate status

___ New candidate

_X_ Continuing candidate

___ Non-petitioned

_X_ Petitioned - Date petition received: May 11, 2004

_ 90-day positive - FR date:

_ 12-month warranted but precluded - FR date:

_ Did the petition requesting a reclassification of a listed species? No

FOR PETITIONED CANDIDATE SPECIES:

a. Is listing warranted (if yes, see summary of threats below)? Yes

b. To date, has publication of a proposal to list been precluded by other higher priority listing actions? Yes

c. If the answer to a. and b. is “yes”, provide an explanation of why the action is precluded.

We find that the immediate issuance of a proposed rule and timely promulgation of a final rule for this species has been, for the preceding 12 months, and continues to be, precluded by higher priority listing actions (including candidate species with lower LPNs). During the past 12 months, most of our national listing budget has been consumed by work on various listing actions to comply with court orders and court-approved settlement agreements, meeting statutory deadlines for petition findings or listing determinations, emergency listing evaluations and determinations, and essential litigation-related, administrative, and program management tasks. We will continue to monitor the status of this species as new information becomes available. This review will determine if a change in status is warranted, including the need to make prompt use of emergency listing procedures. For information on listing actions taken over the past 12 months, see the discussion of “Progress on Revising the Lists,” in the current CNOR which can be viewed on our Internet website (http://endangered.fws.gov/).

_ Listing priority change

Former LP: __

New LP: _

Date when the species first became a Candidate (as currently defined): October 30, 2001

___ Candidate removal: Former LP: ___

___ A – Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status.

____U – Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species.

___ F – Range is no longer a U.S. territory.

___ I – Insufficient information exists on biological vulnerability and threats to support listing.

___ M – Taxon mistakenly included in past notice of review.

___ N – Taxon does not meet the Act's definition of "species."

___ X – Taxon believed to be extinct.

ANIMAL/PLANT GROUP AND FAMILY: Amphibians; Salamanders – Family Cryptobranchidae

HISTORICAL STATES/TERRITORIES/COUNTRIES OF OCCURRENCE: Arkansas, Missouri

CURRENT STATES/ COUNTIES/TERRITORIES/COUNTRIES OF OCCURRENCE:
Arkansas: Baxter, Fulton, Independence, and Randolph
Missouri: Carter, Dent, Douglass, Howell, Ozark, Oregon, Reynolds, Ripley, Shannon, Texas, and Wright

LAND OWNERSHIP:
Ozark hellbender distribution in Missouri is primarily on private land with a few records from conservation areas managed by the Missouri Department of Conservation and U.S. Forest Service Lands in the Mark Twain National Forest, and National Park Service lands in the Ozark National Scenic Riverways (Current and Jacks Fork Rivers).

LEAD REGION CONTACT: Laura Ragan, 612-713-5157

LEAD FIELD OFFICE CONTACT: Charles Scott, 573-234-2132, extension 104

BIOLOGICAL INFORMATION:
<u>Species Description</u>
The Ozark hellbender is a large, strictly aquatic salamander endemic to streams of the Ozark plateau in southern Missouri and northern Arkansas. Its dorso-ventrally flattened body form enables movements in the fast flowing streams it inhabits (Wagner et al. 1999). Hellbenders have a large, keeled tail and tiny eyes. Adult Ozark hellbenders may attain total lengths of 29 - 57 cm (Dundee and Dundee 1965, Johnson 1987). Numerous fleshy folds along the sides of the

body provide surface area for respiration (Nickerson and Mays 1973a) and obscure poorly developed costal grooves (Dundee 1971). Ozark hellbenders are distinguishable from eastern hellbenders (*Cryptobranchus alleganiensis alleganiensis)* by their smaller body size, dorsal blotches, increased skin mottling, heavily pigmented lower lips, smooth surfaced lateral line system, and reduced spiracular openings (Grobman 1943, Dundee 1971, Peterson et al. 1983, LaClaire 1993).

Taxonomy

The Ozark hellbender (*Cryptobranchus alleganiensis bishopi*) was originally designated as *C. bishopi* by Grobman (1943) from a specimen collected from the Current River in Carter County, Missouri. Due to the small amount of genetic variation in the genus *Cryptobranchus* (Merkle et al. 1977, Shaffer and Breden 1989), Schmidt (1953) referred to the Ozark hellbender as a subspecies of the eastern hellbender, *C. alleganiensis*, and this was supported by Dundee and Dundee (1965). This designation persisted until Collins (1991) revived *C. bishopi*, due to the lack of intergradation between the eastern and Ozark hellbenders because of the allopatry of the populations (Dundee 1971). Although Ozark hellbenders have been shown to be phenotypically and genetically distinct from eastern hellbenders (Grobman 1943, Dundee and Dundee 1965, Dundee 1971, Routman 1993, Wagner et al. 1999), the U.S. Fish and Wildlife Service will continue the use of *C. a. bishopi*, which is the name currently recognized by the Center for North American Herpetology (Collins and Taggart 2002). Although discussion continues over the taxonomic status of the Ozark hellbender, the designation of the Ozark hellbender as a species or subspecies does not affect its qualification for listing under the Endangered Species Act (87 Stat. 884, as amended: 16 U.S.C. 1531 et seq.). Careful review of the Ozark hellbender's taxonomic information confirms it is a valid species.

Habitat

Eastern and Ozark hellbenders are very similar in habitat selection, movement, and reproductive biology (Nickerson and Mays 1973a). Published works on the eastern hellbender may provide insights into Ozark hellbender ecology. Adult Ozark hellbenders are frequently found beneath large rocks in moderate to deep (< 1m – 3m), rocky, fast-flowing streams in the Ozark plateau (Johnson 1987, Fobes and Wilkinson 1995, Wagner et al. 1999). In spring-fed streams, Ozark hellbenders will often concentrate just downstream of the area where there is little water temperature change throughout the year (Dundee and Dundee 1965). Adults are nocturnal, remaining beneath cover during the day and emerging to forage at night, primarily on crayfish. They are diurnal during the breeding season (Nickerson and Mays 1973a, Noeske and Nickerson 1979, Collins 1997). Ozark hellbenders are territorial and will defend occupied cover from conspecifics (Nickerson and Mays 1973a). This species migrates little, with one tagging study revealing that 70 percent of marked individuals moved less than 30 meters from the site of original capture (Nickerson and Mays 1973b). Home ranges average 28 square meters for females and 81 square meters for males (Peterson and Wilkinson 1996).

Typically, Ozark hellbender populations are dominated by older, large adults (Nickerson and Mays 1973a, Peterson et al. 1983, LaClaire 1993). Juveniles reach sexual maturity between 5 and 8 years, with males maturing at a smaller size and younger age than females. Ozark hellbenders may live 25 - 30 years in the wild (Peterson et al. 1983). Breeding generally occurs between September and November. Populations in the Spring River, Arkansas, however, breed in January (Peterson et al. 1983). Ozark hellbenders mate via external fertilization, and males will guard the fertilized eggs from predation by conspecifics (Nickerson and Mays 1973a). Clutch sizes vary from 138 to 450 eggs per nest (Dundee and Dundee 1965, Zug 1993), and eggs hatch after approximately 80 days (Zug 1993). Hatchlings and larvae are rarely collected during surveys, due to low detectability. Larvae and small individuals hide beneath small stones in gravel beds (Nickerson and Mays 1973a, LaClaire 1993).

Range/Distribution

Ozark hellbenders are endemic to the Black and White River drainages in Arkansas and Missouri (Johnson 1987) in portions of the Spring, White, Eleven Point, and Current Rivers and their tributaries (LaClaire 1993).

Population Estimates/Status

Ozark hellbenders are believed to be declining throughout their range (Wheeler et al., 2003), and no populations appear to be stable. Declines have been evident throughout the range of the eastern hellbender as well, which receives protective status in many eastern states. Because the two subspecies are very similar, closer scrutiny has revealed a similar, more recent decline in Ozark hellbenders. A description of what is known about Ozark hellbender populations follows.

White River System

White River- There are only two hellbender records from the main stem of the White River. In 1997, a hellbender was recorded in Baxter County, Arkansas (Dr. Stanley Trauth, Arkansas State University, pers. com.). No hellbenders were found during a 2001 survey of the lower portion of the White River, but in 2003, an angler caught a specimen in Independence County, Arkansas (Kelly Irwin, Arkansas Game and Fish Commission, pers. comm.). It is not known whether a viable population exists in the main stem of the White River or if the individuals captured are members of a relic population that was separated from the North Fork White River population by Norfork reservoir. Much of the hellbender habitat was destroyed by the series of dams constructed in the 1940s and 1950s on the upper White River, including Beaver, Table Rock, Bull Shoals, and Norfork reservoirs.

North Fork White River- The North Fork White River historically contained a considerable hellbender population. In 1973, results of a mark-recapture study indicated approximately 1,150 hellbenders within a 2.67 kilometer (km) reach of river in Ozark County, Missouri, with a density of one individual per eight to ten square meters (m^2) (1/8-10 m^2) (Nickerson and Mays 1973b). Ten years later, hellbender density in a 4.6 km section of the North Fork White River in the same county remained rather high, with densities between one per six to seven m^2 and one per 13 to 16 m^2 (Peterson et al. 1983). Individuals caught in this study also represented a range of lengths (172 - 551 millimeters (mm)), indicating that reproduction was occurring in this population, and most individuals were sized at between 250 - 449 mm. Subsequently, in a 1992 qualitative study in Ozark County, Missouri, 122 hellbenders were caught during 49 person-hours of searching (Ziehmer and Johnson 1992). These individuals ranged from 254 - 457 mm, and no average size was included in this publication.

Up until the 1992 study, the North Fork White River population appeared to be fairly healthy. However, in a 1998 study of the same reach of river censused in 1983 (Peterson et al. 1983) and using the same collection methods, only 50 hellbenders were captured (Wheeler et al. 1999). These individuals ranged in length from 200 - 507 mm, with most being between 400 - 500 mm, and were on average significantly longer than those collected twenty years earlier (Wheeler 1999). This shift in length distribution was not a result of an increase in maximum length of individuals; instead, there were fewer individuals collected in the smaller size classes. In order to compare results between these qualitative and quantitative studies, Wheeler et al. (1999) converted historical hellbender collections (Peterson et al. 1983) to numbers of individuals caught per day. In addition, the other studies that were not included in that conversion (Peterson 1983, Peterson 1988, Ziehmer and Johnson 1992) have been converted here. For comparison purposes, one search day is defined as 8 hours of searching by 3 people (i.e., 24 person-hours). Although this search day may be an underestimate of actual effort, a conservative estimate of effort will result in a conservative estimate of hellbender population declines. Therefore, in 1983, approximately 51 hellbenders were caught per sampling day (Peterson et al. 1983). In 1992, 60 hellbenders/day were caught (Ziehmer and Johnson 1992), and, in 1998, 16 hellbenders/day were caught (Wheeler 1999). Based on these comparisons, a decline in the North Fork White River population is evident.

The North Fork White River had been considered the stronghold of the species in Arkansas and Missouri, and the populations inhabiting this river were deemed stable (Ziehmer and Johnson 1992, LaClaire 1993). These populations, however, now appear to be experiencing declines similar to those in other streams. The collection of young individuals has become rare, indicating little recruitment. However, Briggler (pers. comm. Nov. 2005) did find smaller hellbenders in this river during his 2005 surveys. In species such as the hellbender, which are long lived and mature at a relatively late age, detecting declines related to recruitment can take many years, as recruitment under healthy population conditions is typically low (Nickerson and Mays 1973a). A gradual, long-term decline appears to be occurring in the North Fork White River, although quantitative studies are needed to determine the likely effects of this decline on the population.

Bryant Creek- Bryant Creek is a tributary of the North Fork White River in Ozark County, Missouri, which flows into Norfork Reservoir. Ziehmer and Johnson (1992) expected to find hellbenders in this stream during an initial survey, but none were captured or observed after 22 person-hours. This apparent lack of the species conflicted with reports from Missouri Department of Conservation (MDC) personnel and an angler who reported observations of fairly high numbers of hellbenders in Bryant Creek during winter months (Ziehmer and Johnson 1992). A subsequent survey of the creek resulted in the capture of six hellbenders (Wheeler et al. 1999), confirming the existence of a population in this tributary. This population, however, is isolated from the other North Fork White River populations by Norfork reservoir, which could contribute to this population's apparent small size.

Black River System

Black River- There is one documented record of a hellbender in the Black River in Independence/Jackson County, Arkansas in 1978 (K. Irwin, pers. comm.). Portions of the Black River in Missouri were surveyed in 1999 by researchers at Arkansas State University, but no hellbenders were observed (Wheeler et al. 1999). Currently, the Black River does not appear to have conditions suitable for hellbenders, although it may have been occupied before intensive agricultural practices were begun in the area (K. Irwin, pers. comm.). Furthermore, the Black River is presumed to be part of the historic range of the species, due to the presence of hellbenders in several of its tributaries, including the Spring, Current, and Eleven Point Rivers (Firschein 1951, Trauth et al. 1992).

Spring River- The Spring River, a tributary of the Black River, flows from Oregon County, Missouri, south into Arkansas. Hellbender populations have been found in the Spring River near Mammoth Spring, Fulton County, Arkansas (LaClaire 1993). In the early 1980's, 370 individuals were captured during a mark-recapture study along 7 km of stream south of Mammoth Spring (Peterson et al. 1988). Hellbender density at each of the two surveyed sites was fairly high (approximately one per 23 m^2 and one per 111 m^2). These individuals were considerably larger than hellbenders captured from other streams during the same time period, with 74 percent of Spring River hellbenders measuring over 450 mm total length (maximum 600 mm) (Peterson et al. 1988). This may indicate that Spring River populations are genetically distinct from other hellbender populations. This conclusion was upheld by a genetic study of the Spring, Current, and Eleven Point River populations (Wagner et al. 1999). In 1991, a longer reach (26 km) was surveyed for hellbenders, and only 20 were observed during 41 search hours over a 6 month period, at many of the same sites sampled by Peterson et al. (1983) (Trauth et al. 1992). No size class information is available, although the large sizes of the 1988 captures may be indicative of a population experiencing little recruitment.

Researchers with Arkansas State University surveyed the Spring River during the fall 2003 through spring 2004, performing 50 hours of search effort and finding only four Ozark hellbenders. These animals were removed from the river and are currently being housed at the Mammoth Spring National Fish Hatchery. It is apparent that hellbenders have declined in this stream and have likely succumbed to water quality degradation, aquatic vegetation encroachment, and illegal commercial collection (K. Irwin, pers. comm.).

Eleven Point River- The Eleven Point River, a tributary of the Black River, has been surveyed several times since the 1970's. Historical data provided by Peterson was analyzed by Wheeler (1999). In 1978, 87 hellbenders were captured in Oregon County, Missouri, over a 3-day period, yielding 29 hellbenders/day. From 1980 to 1982, 314 hellbenders were captured in the same area in 9 collection days, yielding 35 hellbenders/day. Hellbender body lengths over that period ranged from 119 - 451 mm. In 1988, Peterson et al. (1988) captured 211 hellbenders from the Eleven Point River and estimated hellbender density to be approximately one per 20 m^2. Total lengths of these individuals ranged from 120 - 450 mm, with most between 250 - 350 mm. Although the data were not analyzed for captures per day, it can be estimated that approximately 40 hellbenders were caught per day during this study. Wheeler (1999) captured 36 hellbenders over 4 days from Peterson et al.'s (1988) localities, for an average of 9 hellbenders/day. These hellbenders were larger than those captured previously, with total lengths of 324 - 457 mm, and there were significantly fewer individuals in the smaller size classes. The population appeared stable until 1988 (captures of 29, 35, and roughly 40 hellbenders/day), and then dropped to 9 hellbenders/day 10 years later, and these individuals were considerably larger than those caught previously. Although population declines and reduced recruitment in the Eleven Point River in Missouri is indicated, hellbenders are consistently reported during surveys in the Eleven Point River in Arkansas (K. Irwin, pers. comm.).

Current River- The Current River had not been surveyed extensively until the 1990s. Nickerson and Mays (1973a) reported a large population in this stream, but no numbers were presented. In 1992, Ziehmer and Johnson (1992) found 12 hellbenders in 60 person-hours in Shannon County, Missouri, or approximately 5 hellbenders/day, using the same search day conversion as presented above. These individuals ranged in length from 115 mm to more than 380 mm (maximum length was not reported), with most between 330 mm and 380 mm. Seven years later, 14 hellbenders were collected over 3 collection days (approximately 5 hellbenders/day), also in Shannon County, Missouri, and the individuals ranged from 375 - 515 mm, with most between 450 - 499 mm (Wheeler 1999). It appears that this population is small, and may not be declining. The average size of individuals, however, has increased by nearly 100 mm, and this population shows a lack of recruitment.

Jacks Fork- Jacks Fork, a tributary of the Current River, was surveyed for hellbenders for the first time in 1992 (Ziehmer and Johnson 1992). Four hellbenders were collected over 66 person-hours, roughly 2 hellbenders/day. The individuals were large, ranging from 330 - 430 mm. No hellbenders have been found during subsequent investigations of Jacks Fork.

The first annual MDC hellbender survey week was held from August 12 thru August 15, 2003 on the Jacks Fork and Current River. The main purpose of this survey was to determine possible long-term monitoring sites as well as assess hellbender status in selected stretches of these rivers. Using mask and snorkel, surveyors overturned rocks within suitable habitat. In some cases, potential habitat was too deep or the current was too swift to survey. At each location, latitude and longitude, effort (time), and number of individuals searching for hellbenders were recorded. All hellbenders observed were sexed, measured (total length --TL), and checked for PIT tags. Also, notes were recorded on abnormalities and ectoparasites (leeches). Twenty-one locations (7 on the Jacks Fork and 14 on the Current River) were mapped and searched for hellbenders in which three of these sites on the Current River contained hellbenders. The survey lasted 4 days, in which 3 hellbenders were found on the third day of the survey. Total lengths of these animals were 15 inches (sex unknown), 16 inches (male) and 21 inches (male). In addition, a comprehensive survey of the Jacks Fork and Current Rivers is being conducted in 2006 by the National Park Service, however, data from this effort are not yet available.

THREATS:

A. The present or threatened destruction, modification, or curtailment of its habitat or range. The decline of the Ozark hellbender in the White and Black River systems in Missouri and Arkansas is likely the result of habitat degradation in the form of impoundments, ore and gravel mining, sedimentation, nutrient runoff, and nest site disturbance due to recreational uses of the rivers it inhabits (Williams et al. 1981, LaClaire 1993). Although the precise causes of hellbender declines are likely complex interrelationships among threats and the species' life history characteristics, habitat degradation is the most frequent cause of lotic faunal declines (Allan and Flecker 1993). Hellbenders are habitat specialists that depend on constant levels of dissolved oxygen, temperature, and flow (Williams et al. 1981). Therefore, even minor alterations to stream habitat are likely detrimental to hellbender populations.

Impoundment

Impoundments impact stream habitat in many ways. When a dam is built on a freeflowing stream, riffle and run habitats are converted to lentic, deep water habitat. As a result, surface water temperatures tend to increase and dissolved oxygen levels tend to decrease, due to the lentic conditions of the water (Allen 1995). Because hellbenders are habitat specialists, they cannot tolerate a wide range of habitat conditions. Hellbenders depend upon highly vascularized lateral skin folds for respiration; therefore, lakes and reservoirs are unsuitable habitat for Ozark hellbenders, as these areas have lower oxygen levels and higher water temperatures (Williams et al. 1981, LaClaire 1993) than do fast flowing, cool water, highly oxygenated stream habitats. Impoundments also act to fragment hellbender habitat, blocking the flow of immigration and emigration between populations in addition to preventing recolonization from source populations (Dodd 1997). Small isolated populations are more susceptible to environmental perturbation and demographic stocasticity, both of which may lead to local extinction (Lande 1988, Wyman 1990).

In the upper White River, construction of Beaver, Table Rock, Bull Shoals, and Norfork dams in the 1940's and 1950's has destroyed much of the historic hellbender habitat that occurred there and has effectively isolated hellbender populations. Norfork dam was constructed on the North Fork White River in 1944 and has isolated Ozark hellbender populations in Bryant Creek and the White River from those in the North Fork White River. Additionally, populations downstream of Beaver, Table Rock, Bull Shoals, and Norfork dams were extirpated due to hypolimnetic releases from the reservoir. These releases are much cooler than normal stream temperatures, and the water in such releases is typically depleted of oxygen. In addition, the tailwater zones below dams experience extreme water level fluctuations and scouring for many miles downstream which impact hellbender populations by washing out the pebbles and cobbles used as cover by juveniles and creating unpredictable habitat conditions that fluctuate outside the Ozark hellbender's range of tolerance.

Mining

Gravel mining has occurred in many southeastern streams, including a number of streams within the historic range of the Ozark hellbender, which has contributed to Ozark hellbender habitat alteration and loss. Dredging results in stream instability both up and downstream of the dredged portion (Neves et al. 1997, Box and Mossa 1999). Head cutting, in which the increase in transport capacity of a dredged stream causes severe erosion and degradation upstream, results in extensive bank erosion, sloughing, and increased turbidity levels (Allan 1995). Reaches downstream of the dredged stream reach often experience aggradation as the sediment transport capacity of the stream is reduced (Box and Mossa 1999). These activities disturb hellbender den sites in dredged areas, and associated silt plumes can cover downstream den sites. In addition, these effects reduce crayfish populations, which are the primary prey species for Ozark hellbenders. Gravel dredging is widespread in the White and Black River systems in southern Missouri and northern Arkansas (LaClaire 1993). Both large and small sand and gravel mining operations are prevalent throughout the Ozarks. The 1998, U.S. District Court of Appeals (Tulloch Rule) decision resulted in the deregulation of gravel removal activities by the U.S. Army Corps of Engineers. The court found that "de-minimus" or incidental fall back of sand and gravel into the stream from which it was being excavated did not constitute the placement of fill by the mining operation. Hence, the court ruled that the Army Corps of Engineers had exceeded their authority in requiring a permit for this activity. Although these activities no longer require a Clean Water Act 404 permit, commercial operations must apply for a State permit through the Missouri Department of Natural Resources Land Reclamation Program. These permits, however, do not go through a federal review process. Modifications of stream channels associated with gravel mining, as well as the removal of pebbles and cobble that are important microhabitat for larvae and subadults, contribute to the decline of Ozark hellbenders in these systems.

Portions of the Ozark plateau have a history of being major producers of lead and zinc, and some mining activity still occurs in the southeastern Ozarks, though at less than historic levels. Results of a recent USGS water quality study in the Ozark plateau revealed that concentrations of lead and zinc in bed sediment and fish tissue were substantially higher at sites with historical or active mining activity and that these concentrations were high enough to suggest adverse biological effects, such as reduced enzyme activity or death of aquatic organisms. Although mining for lead and zinc no longer occurs within the range of the Ozark hellbender, elevated concentrations are still present in the streams where mining occurred historically (Petersen et al. 1998).

Water Quality
Despite the claim by some that many Ozark streams outwardly appear to exist in pristine conditions, Harvey (1980) clearly demonstrated that various sources of pollution exist in the ground water in the Springfield-Salem Plateaus of southern Missouri. In comparing ground-water quality of sites within the Ozark Plateaus (including Arkansas and Missouri) with other National Water-Quality Assessment Program (NAWQA) sites, Petersen et al. (1998) documented that: 1) nitrate concentrations in parts of the Springfield Plateau aquifer were higher than in most other NAWQA drinking-water aquifers, and 2) volatile organic compounds were detected more frequently in drinking-water aquifers within the Ozark Plateaus than in most other drinking-water aquifers. These studies overlap well with the current distribution of Ozark hellbenders in Arkansas and Missouri.

Nitrogen and phosphorus are essential plant nutrients that are found naturally in streams. However, elevated concentrations of these nutrients causes excessive growth of aquatic algae and plants in many streams and has detrimental effects upon water quality. Contamination of water in the Ozark plateau by nutrients has occurred from runoff of poultry and cattle wastes, human wastes, and fertilizers. National Water Quality-Assessment data collected in the Ozarks in 1993-1995 from wells and springs indicated that nitrate concentrations were strongly associated with the percentage of agricultural land near the wells or springs. In addition, fecal coliform levels have been elevated in these areas (Petersen et al. 1998). Livestock wading in streams, poor agricultural practices that lead to the degradation of riparian buffer zones, and faulty septic and sewage treatment systems have resulted in these elevated levels, which cause more algae to grow on streambed rocks. This growth affects aquatic species composition and causes benthic-feeding organisms to thrive (Petersen et al. 1998). Agriculture comprises approximately 30 percent of the land use within the range of the Ozark hellbender, which is intolerant of nutrient pollution (Nickerson and Mays 1973a).

Siltation
Sediment inputs from land use activities have significantly contributed to habitat degradation. Hellbenders are intolerant of sedimentation and turbidity (Nickerson and Mays 1973a) and can be impacted by these in several ways. First, sediment deposition of cover rocks reduces or removes suitable habitat for adults and can cover and suffocate eggs. Second, sediment will fill in interstitial spaces in pebble/cobble beds, reducing suitable habitat for larvae and subadults (FISRWG 1998). Third, suspended sediment loads can also cause water temperatures to increase, as there are more particles to absorb heat, thereby reducing dissolved oxygen levels (Allen 1995). Again, the Ozark hellbender requires cool water temperatures and high levels of dissolved oxygen, perturbations to environmental conditions can be detrimental to hellbender populations. Fourth, sedimentation can impede the movement of individuals and colonization of new habitat may only occur when rivers have low sediment loads (Routman 1993). Fifth, the Ozark hellbender’s highly permeable skin causes them to be negatively affected by sedimentation. Various chemicals, such as pesticides, bind to silt particles and become suspended in the water column when flushed into a stream. The hellbender’s permeable skin provides little barrier to these chemicals, which can be toxic (Blaustein and Wake 1990, Wheeler et al. 1999). Additionally, sedimentation may result in a decline of prey abundance by embedding cover rocks.

Timber harvesting is prominent in many areas within the range of the Ozark hellbender. Logging roads probably introduce the bulk of suspended sediment through erosion from road construction and the sediment-transporting ability of constructed roads. Roads can also cause marginally stable slopes to fail, and they capture surface runoff and channel it directly into streams (Allan 1995). Erosion from roads contributes more sediment than the land harvested for timber (Box and Mossa 1999). Peak stream flows often rise in watersheds with timber harvesting activities, due in part to compacted soils resulting from roads, landings, and vegetation removal (Allan 1995, Box and Mossa 1999). The cumulative effects of timber harvest on sedimentation rates last for many years, even after harvest practices have ceased in the area (Frissell 1997).

Solis et al. (2005c) analyzed water samples from the North Fork of the White River and the Eleven Point River to assess the presence of endocrine disrupting chemicals and nutrient levels. Seven possible endocrine disrupting chemicals were present (organic chemicals, plasticizers, herbicides, and pesticides); however, the concentrations were below the Environmental Protection Agency (EPA) criteria and below Missouri Clean Water Commission criteria for aquatic life.

Disturbance

Habitat disturbance may also be affecting hellbender survival in several rivers. Most rivers and streams inhabited by hellbenders are extremely popular with canoeists, kayakers, rafters, inner tube floaters, or small horsepower motorboats. Hellbenders encountered with gashes cut in their heads, suggest that heavy watercraft traffic probably takes its toll on these animals. Although no data are available that support this assertion, it has been speculated that the disturbance of den sites by watercraft may lead to the abandonment of those sites. All-terrain vehicle (ATV) recreation is also widespread throughout the Ozarks region. Unfortunately, ATVs frequently cross hellbender rivers and drive in riverbeds where the water is shallow enough to permit this form of recreation. The force delivered by a boat or ATV hitting a rock might easily injure or kill hellbenders.

In addition, the practice of removing large rocks and boulders (by hand, machinery, or dynamite) to reduce damage to canoes is common on many hellbender streams (Nickerson and Mays 1973a, Wheeler et al. 1999). The areas under these large rocks are important habitat for cover and nest sites, so if these rocks are removed, the amount of available cover and nest sites is diminished.

B. <u>Overutilization for commercial, recreational, scientific, or educational purposes</u>.
Anecdotal reports indicate that Ozark hellbenders have been collected for commercial and scientific purposes (Trauth et al. 1992). Although commercial collections are currently illegal in both Missouri and Arkansas, once removed, hellbenders can be legally sold to pet wholesalers in states where restrictions have not been enacted.

In Arkansas, hellbenders may be collected with a permit from the Arkansas Game and Fish Commission, however, no permits are being issued at this time unless they are for specific research projects directed by AGFC (K. Irwin, AGFC, pers. comm.). Missouri imposed a moratorium on hellbender collecting from 1991 to 1996 and has since only allowed limited numbers of collecting permits (P. Horner, Missouri Department of Conservation, pers. comm.). Nonetheless, illegal collecting for the pet trade has been documented, and remains a threat. There is one report of over 100 hellbenders illegally collected in the 1980s in Missouri (P. Horner, Missouri Department of Conservation, pers. comm.), and as recently as the early 1990s, hellbenders were still being illegally collected in Arkansas (J. Briggler, K. Irwin, pers. comm.).

Recreational fishing may also negatively impact Ozark hellbender populations, due to an unfounded animosity towards hellbenders, which are thought to be poisonous and/or to interfere with fisheries production (Gates et al. 1985). In addition, there are unpublished reports of hellbenders accidentally killed by frog giggers, who may gig a hellbender inadvertently. The gigging season spans the reproductive season of the Ozark hellbender in the North Fork of the White River and overlaps that of the hellbender in other river basins as well. Nickerson and Mays (1973a) in their studies of Missouri hellbenders found dead gigged specimens and Metter (pers. comm. with Nickerson 1972) has data showing how susceptible they are to this threat.

When considered cumulatively, collection and illegal or unintentional harvest is a threat to many of the declining hellbender populations. Because the species is long lived and does not reproduce until approximately age 7, the removal of even a few individuals from a population that is experiencing declines can impact the recruitment potential of that population. Presently, collecting levels appear reduced (LaClaire 1993), but collecting could become more of a threat if populations continue to decline.

C. Disease or predation.

The occurrence of disease is virtually unknown in Ozark hellbender populations and has been little studied. Although young hellbenders are occasionally preyed upon by large fish, turtles, and water snakes, this is rare due to their noxious skin secretions and likely does not occur after hellbenders reach 380 mm (Nickerson and Mays 1973a, Peterson et al. 1983). It is unlikely an otherwise healthy population would be threatened by natural levels of predation.

In the Ozark region, both brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) have been sporadically introduced into Missouri waters for recreational fishing purposes since the 1800s. In recent decades, stocking of trout by the Missouri Department of Conservation (MDC) and the Arkansas Game and Fish Commission has been extensive and systematic. For example, between 1962 and 1998, releases of rainbow trout into the Eleven Point River averaged 11,650 individuals per year (MDC web-site, 2003). In recent years, MDC has released nonnative trout into all Missouri rivers that have historically contained hellbenders (rainbow trout: Niangua, Gasconade, Big Piney, Current, North Fork of White, and Spring rivers; brown trout: Niangua, Gasconade, North Fork of White, and Current rivers) (MDC web-site, 2002).

Both rainbow trout and brown trout have a diverse diet, eating almost any animal small enough to fit into their mouths, including amphibians (DNR-Maryland web-site, 2000a,b). Brown trout grow bigger and tolerate a wider range of habitats than rainbow trout and, therefore, may be a particularly serious threat to hellbenders. Dunham et al. (2004) assessed the impacts of nonnative trout in headwater ecosystems in western North America. The authors documented at least eight amphibian species that exhibited negative associations with nonnative trout in mountain lakes, specifically with regards to the occurrence or abundance of larval life stages of native amphibians.

Reductions in survival of offspring due to predation by nonnative trout are potentially an additional cause or exacerbating factor for the observed population declines of hellbender populations west of the Mississippi River. Introduced fishes have been shown to have dramatic negative effects on populations of amphibians in other areas (e.g., Bradford, 1989; Frank and Dunlap, 1999; Gillespie, 2001). Preliminary data suggest that larval hellbenders from declining populations in Missouri do not recognize brown trout as dangerous predators. In contrast, larvae from more stable southeastern populations that co-occur with native trout show “fright” responses to brown trout (A. Mathis, pers. comm.).

Trauth and Wheeler (2003) investigated morphological aberrations in the hellbender over a 10 year period. They obtained deformity data from salamanders that were examined during population and distributional surveys in the Eleven Point River, North Fork of the White River, and Spring River dating back to 1991. They found a variety of abnormal limb structures, including missing toes, feet, and limbs. Additional abnormalities encountered include epidermal lesions, blindness, missing eyes, and bifurcated limbs. Three hellbenders were documented with tumors on their bodies in the Spring River in Arkansas. Currently, there are no data available to correlate these abnormalities with the recent precipitous decline in hellbenders observed in these rivers. Briggler (pers. comm. November 2005) is evaluating and compiling additional information on these abnormalities and lesions including the frequency of occurrence. Several hellbenders with these abnormalities have been x-rayed and are being analyzed by Jeff Briggler, Missouri Department of Conservation. Two hellbenders with abnormalities are scheduled for necropsy USGS's Wildlife Disease Lab in Madison, Wisconsin.

D. <u>The inadequacy of existing regulatory mechanisms</u>.
The states of Arkansas and Missouri prohibit the taking of Ozark hellbenders for any purpose without a state scientific collecting permit. However, enforcement of this permit requirement is difficult. Additionally, state regulations do not protect hellbenders from other threats. Existing authorities available to protect riverine ecosystems, such as the Clean Water Act (CWA), administered by the EPA and the U.S. Army Corps of Engineers, may not have been fully exercised in an effort to prevent in-stream activities and the resulting habitat degradation. This may have contributed to the general habitat degradation apparent in riverine ecosystems and decline of both eastern and Ozark hellbender populations throughout their ranges. Although the Ozark hellbender coexists with other federally listed species throughout parts of its range, listing under the Endangered Species Act would provide additional protection, as the threats to hellbenders and the other endangered species are not identical.

The illegal and legal collection of hellbenders for research purposes, museum collections, zoological exhibits, and the pet trade has undoubtedly been a contributing factor to hellbender declines. A manuscript currently in preparation by M.A. Nickerson, J. T. Briggler, and C. Hughes, documents the removal of more than 550 hellbenders (approximately 300 animals were illegally removed) from the North Fork of the White River from 1969 to 1989. Anecdotal information exists that suggests that illegal collection of animals on the Spring River in Arkansas contributed significantly to the recent population crash, as river reaches that formerly contained 35 to 40 individuals currently harbor no hellbenders (K. Irwin pers. comm.) Presently, the collection of hellbenders for research purposes is very low, primarily due to the rigorous permitting process and special state protection status. Regardless, the possibility of illegal collection of hellbenders is a major concern. With increased attention to these animals and an increase in market rates (a pet dealer in Florida was advertising hellbenders for sale at $175 a piece in 2003); it would prove worthwhile to illegally trade hellbenders, especially as violators are not likely to be prosecuted. A review of collection regulations in States with hellbenders is currently being conducted to determine the level of protection for each State. This information is needed to determine if listing the hellbender under the Convention on International Trade in Endangered Speices is appropriate.

Currently, there are no regulations governing best management practices (BMPs) of timber harvesting, which would reduce impacts on water quality. Existing BMPs are established by the Arkansas Forestry Commission and Missouri Department of Conservation and lack mandatory requirements for implementing methods to reduce aquatic resource impacts associated with timber harvests. Many timber harvests involve clear-cutting to the streambank, which promotes bank erosion.

E. <u>Other natural or manmade factors affecting its continued existence</u>.

Genetic Variation

Certain population characteristics of hellbenders cause the species to be fairly vulnerable to extirpations and extinction. The hellbender, having specialized habitat requirements, is extremely vulnerable to environmental perturbations and small populations are less likely to rebound following these perturbations. In addition, hellbenders exhibit very low genetic diversity (Merkle et al. 1977, Shaffer and Breden 1989, Wagner et al. 1999), which is consistent with habitat specialization (Nevo 1978, Wagner et al. 1999). Hellbenders have adapted to a relatively constant environment and, therefore, several structural, behavioral, and physiological specializations have resulted (Williams et al. 1981). These specializations, in combination with the stable environment, seem to have resulted in very low levels of genetic diversity (Wagner et al. 1999). Fragmentation of populations by impoundments, habitat degradation, and other impediments to dispersal may exacerbate this situation. Without the level of interchange the hellbender experienced historically, many small, isolated populations do not receive the influx of new genetic material that once occurred.

As the populations decrease in size, genetic diversity is lost and inbreeding can occur. Inbreeding may result in decreased fitness, and the loss of genetic heterozygosity can result in a significantly increased risk of extinction in localized natural populations (Saccheri et al. 1998). The loss of genetic diversity is illustrated by Routman's (1983) study, in which hellbender populations from different rivers showed very little within-population variability, and relatively high between-population variability. Due to this population fragmentation, local extinctions cannot be naturally repopulated.

Recruitment

Hellbenders are long-lived, capable of living up to 55 years in captivity (Nigrelli 1954) and up to 35 years in the wild (Taber et al. 1975, Petranka 1998). Individuals mature sexually when 5-8 years of age (Bishop 1941a, Dundee and Dundee 1965) and males normally mature at a smaller size and younger age than females. Female hellbenders are reported to be sexually mature at a total length of 37-39 cm, or approximately 6-8 years of age (Nickerson and Mayes 1973a, Peterson et al. 1983, Taber et al. 1975). Male hellbenders have been reported to reach sexual maturity at a total length of 30 cm, or approximately 6-7 years of age (Taber et al. 1975).

During or shortly after oviposition, males and females may prey upon their own and other individuals' clutches. Most hellbenders examined during the breeding season contain between 15 and 25 eggs in their stomachs (Smith 1907). Males frequently regurgitate eggs (King 1939, Pfingsten 1990), and females sometimes eat their own eggs while ovipositing them (Nickerson and Mays 1973a). Topping and Ingersol (1981) found that up to 24 percent of the gravid hellbenders examined from the Niangua River in Missouri retained their eggs and eventually reabsorbed them.

The delayed reproduction of hellbenders leads to a higher risk of death prior to reproduction and lengthened generation times (Congdon et al. 1993). Hellbender specimens less than five years of age are uncommon (Taber et al. 1975, Pfingsten 1990) and recent research has indicated that a shift in age structure has resulted in the prevalence of older individuals (Pfingsten 1990, Wheeler et al. 2003). For example, data compiled by the Endangered Species Unit in the state of New York include approximately 150 records of hellbenders from 1883 to 2003 (A. Bresich, pers. comm. with Mayasich et al. 2003). Almost all of these were mature adults; 20 reports include reference to eggs and three indicate that eggs were hatching into larvae. There are no reports , however, of larvae in New York, other than when associated with hatching eggs (A. Bresich, pers. comm. with Mayasich et al. 2003) or in Ohio (R. Pfingsten, pers. comm. with Mayasich et al. 2003).

Because hellbenders are long-lived, a population may not be highly dependent on recruitment to remain extant (R. Pfingsten, pers. comm. with Mayasich et al. 2003). Empirical and theoretical evidence, however, suggests that the amount of generation overlap within a population (i.e., high survivorship among juveniles) is necessary to maintain stable populations (Congdon et al. 1993, Ellner and Hairston 1994). Lack of sufficient recruitment may be limiting population stability as well as the ability of hellbender populations to maintain genetic diversity as alteration of habitat quality occurs within their range (Wheeler et al. 2003). Pfingsten (1990) also cautions, however, that lack of larvae detection could mean that they occupy an unknown microhabitat that has yet to be surveyed.

Several measures of sperm production were compared between male hellbenders in Missouri and males from more stable populations in North Carolina and Georgia (Unger 2003). Sperm counts were significantly lower for males from both Missouri populations than for males from southeastern populations. Populations were not significantly different with respect to sperm viability and motility. The sperm of Missouri males had proportionally smaller heads for their tail lengths; this different was relatively small, but was statistically significant. There is a clear need to direct resources toward determining the cause of the apparent reduction in sperm counts for males from declining populations in Missouri. Because motility and viability appeared unaffected, artificial insemination might be a viable conservation technique, although limited efforts to date have been unsuccessful.

Declines in hellbender populations being observed presently may be the result of activities that occurred years earlier. Because juvenile hellbenders are rarely observed, it takes many years to detect population trends. The lack of recruitment in most hellbender populations is a significant sign that little reproduction has occurred in these populations for several years. Delayed reproduction, when paired with a long life span, can disguise declines until they become fairly severe.

The present distribution and status of Ozark hellbender populations in the White and Black River systems in Arkansas and Missouri may be demonstrating the characteristics mentioned above. Genetic studies have repeatedly demonstrated very low genetic diversity in hellbender populations, which may be a factor in the decline of the species. The current combination of population fragmentation and habitat degradation may prohibit this species from recovering without the intervention of conservation measures designed to facilitate hellbender recovery.

Climate Change

Increasing air and water temperatures over the past 30 years are thought to have seriously influenced declines of amphibian populations worldwide (Pounds 2001). Reliance on cool, well-oxygenated streams may inhibit the ability of hellbenders to acclimate to higher water temperatures. Changing precipitation patterns have resulted in reduced water depths, which may have dried up important hellbender habitat or increased the amount of UV-B radiation penetrating the water column. Kiesecker et al. (2001) documented a connection between pathogen outbreaks in amphibian populations and climate-induced changes in water depth and UV-B exposure. They acknowledge the complex interactions between global climate trends and ecological responses at the local level to UV-B radiation. Caution must be used, however, when assigning causal relationships between climate change and amphibian declines because the pathways are not fully understood (Pounds 2001).

Sympatric Species
There appears to be little concern about the affects of hellbender extirpation on sympatric species. The leech, *Batracobdella cryptobranchii*, has been documented to occur exclusively on Ozark hellbenders. Since this species of leech appears to be specific to one host species, it is also vulnerable to extirpation as Ozark hellbender populations continue to decline.

CONSERVATION MEASURES PLANNED OR IMPLEMENTED:

No conservation agreements have been developed for the hellbender. Missouri and Arkansas, however, are conducting activities that either directly or indirectly help conserve the hellbender. Missouri has provided extra protection for the hellbender in the Wildlife Code of Missouri, outlawing collection of hellbenders, and the species was listed as State Endangered in 2003. In addition, it has been proposed that the sucker gigging season open in early October, with the intention of eliminating the overlap with the hellbender breeding season, when animals are particularly conspicuous and vulnerable. The current season in Missouri opens in September and closes the end of January. Outreach has been considerable in Missouri and Arkansas; signs have been erected throughout the range of the hellbender alerting recreationists to their presence and informing them that hellbenders are harmless and should be left alone or released unharmed if they are caught by anglers. Additionally, numerous stream surveys that document changes in hellbender numbers from the early 1970s to the present have been conducted in those States.

Presently, work is underway at Mammoth Springs National Fish Hatchery to examine potential refugia, propagation, marking, and tracking techniques. The Service has funded a study at Southwest Missouri State University to examine the reproductive status of the species. In addition, the Service is supporting work at the University of Missouri at Rolla to examine potential endocrine disruptors as a cause of hellbender decline. Collaboration is beginning with the Missouri Department of Conservation and the St. Louis Zoo to develop a propagation protocol for the species.

Shortly after the Ozark hellbender was first made a candidate in 2001, the Ozark Hellbender Working Group was formed. This group initially was comprised of dedicated researchers and agency personnel with a common interest in the conservation of hellbenders, but has expanded to include representatives from hatcheries, zoos, and other interested entities. It has become clear that a coordinated effort is necessary to synthesize the current knowledge and to provide guidance and support for hellbender research, conservation, and recovery efforts. The goals of the working group include identifying, prioritizing, and implementing actions necessary to arrest the decline of Ozark hellbenders and restore their populations to self-sustaining levels. This group has collaborated on field work, initiated several research projects, and is working to uncover the primary threat(s) to the species' persistence. In addition, a comprehensive Conservation Strategy is being developed that will include a captive propagation protocol, an outreach strategy, and a watershed protection plan.

A Hellbender Conservation Symposium was co-organized and hosted by Clemson University and the Georgia Department of Natural Resources at Unicoi State Park in Helen, Georgia, July 24-26, 2003. The symposium was well attended by a diversity of individuals representing universities, agencies, zoos, aquariums, private industry, and non-government organizations interested in hellbender conservation. A wide variety of topics were covered including, hellbender status and distribution reports from individual states, current research, status of captive breeding programs, survey and monitoring protocols and techniques, and proactive conservation efforts. Attendees of the symposium agreed that focused research efforts and collaboration between researchers and natural resource managers will be necessary in order to reverse the trend of habitat loss, degradation, and further decline of hellbender populations. The intent was to establish the Hellbender Conservation Symposium as a biennial event. The 2nd Hellbender Conservation Symposium was held June 19-22, 2005 in Lakeview, Arkansas.

The Missouri Department of Conservation is planning to initiate four new hellbender studies in 2006. These studies are:

1. Evaluation of Health Conditions, Reproductive Hormones, and Contaminants in Hellbender: adults and juveniles. This will continue and expand on the baseline information regarding hematology and serum chemistry (Solis and Huang 2005a), reproductive hormones (Solis and Huang 2005b), and chemical and nutrient assessment of hellbender streams (Solis, et al. 2005c).
2. Genetic diversity: estimating gene flow and assessing the distribution of genetic diversity between and among populations inhabiting river systems.
3. Survival and movements of resident adult and released captive-reared Ozark and eastern hellbenders.
4. Effects of Native and Non-native Fish and Larval Hellbenders: Palatability and Behavior Studies

SUMMARY OF THREATS (including reasons for addition or removal from candidacy, if appropriate):
Since the species was elevated to candidate status in 2001, the known threats have increased. In particular, recreational pressures on Ozark hellbender rivers has increased substantially on an annual basis. The MDC reports that gigging popularity and pressure has increased, which presents a significant threat to hellbenders during the breeding season as they tend to move greater distances and congregate in small groups where they are an easy target for giggers. Trout stocking has increased in recent years in Missouri and Arkansas. The 2003 MDC Trout

Management Plan calls for increased levels of stocking as well as increasing the length of cold water streams that will be stocked with brown and rainbow trout (MDC Trout Management Plan 2003). The Arkansas Game and Fish Commission is currently working with the Corps of Engineers to improve cold water releases from mainstem dams along the White River, to improve conditions for trout below the reservoirs (i.e., White River Minimum Flow Study).

Canoe, kayak, and motor/jet boat traffic has increased in recent years on the Jacks Fork, Current, Eleven Point, and North Fork Rivers (K. Irwin, J. Briggler, L. Irwin, N. Poe, J. Eberly, pers. comm.) The popularity of these float streams has grown to the point that the National Park Service is considering alternatives to reducing the number of boats that can be launched daily by concessionaires (N. Poe, pers. comm.) Increased recreational use is also impacting water quality in the area. In 2003, the Missouri Department of Natural Resources added an eight-mile stretch of the Jacks Fork River to the 303(d) list of impaired waters for organic wastes (fecal coliform). Likely sources of the contamination include recreational boaters and tubers, a commercial horse trail ride outfitter, and effluent from campground pit-toilets (Davis and Richards 2002).

Electrofishing as a means to assess fish populations may be lethal to adult, larval, and egg stage hellbenders (M. Nickerson, pers. comm.). A study is currently underway at St. Louis University to determine the validity of these claims (K. Alsup, pers. comm.).

The recently revised U.S. Environmental Protection Agency Consolodated 2002 Missouri 303(d) List included additional Ozark hellbender rivers. A 21 mile stretch of the Eleven Point River was listed as impaired due to unacceptable levels of chlorine and atmospheric deposition of mercury. Water quality monitoring on both the North Fork of the White and Eleven Point Rivers in Missouri detected 21 chemicals and elevated levels of estrogens in male hellbenders collected during 2002 and 2003, respectively (Y. Huang, pers. comm., unpubl. data.).

To date, nothing has been done to reduce or ameliorate ongoing-threats to Ozark hellbenders. The Ozarks region continues to experience rapid urbanization, expansion of industrial agricultural practices such as concentrated animal feeding operations (chickens, turkeys, hogs, cattle), and logging. No laws are in place that preclude livestock from grazing in riparian corridors and loafing in streams and rivers. Missouri is the second largest beef cattle producing state in the nation, with the majority of animal units produced in the Ozarks. Both Arkansas and Missouri are the leading States in poultry production. The fact that the majority of the Ozarks region in Missouri and Arkansas is comprised of karst topography (caves, springs, sinkholes, and losing streams) further complicates the containment and transport of potential contaminants. In short, the over abundance and lack of adequate treatment facilities or practices for both human and livestock waste poses a significant and ever increasing threat to aquatic ecosystems.

The decrease in Ozark hellbender range and population size and the shift in age structure are likely caused by a variety of historic and ongoing activities. The primary cause of these trends is habitat destruction and modification. Among these are impoundment, channelization, and siltation and water quality degradation from a variety of sources, including industrialization, agricultural runoff, mine waste, and timber harvest. Over-utilization of hellbenders for commerce and scientific purposes is also likely contributing to their decline. The regulations in place that could prevent these impacts, including Clean Water Act and state laws, have been inadequate in preventing Ozark hellbender declines to this point. Finally, most of the remaining Ozark hellbender populations are small and isolated, making them vulnerable to individual catastrophic events and reducing the likelihood of recolonization after localized extinctions.

LISTING PRIORITY

THREAT			
Magnitude	Immediacy	Taxonomy	Priority
High	**Imminent**	Monotypic genus	1
		Species	2
		Subspecies/population	**3***
	Non-imminent	Monotypic genus	4
		Species	5
		Subspecies/population	6
Moderate to Low	Imminent	Monotypic genus	7
		Species	8
		Subspecies/population	9
	Non-imminent	Monotypic genus	10
		Species	11
		Subspecies/population	12

Rationale for listing priority number:
Magnitude: The magnitude of the threats to the Ozark hellbender is high. There are multiple significant threats, most of which are present throughout the subspecies' range. Habitat destruction and modification appears to be the primary risk present throughout the range, and much of this threat, such as impoundment, is usually permanent. Impoundment has occurred throughout much of the Ozark hellbender's range, effectively destroying much of the historical habitat that occurred in those waters. Sedimentation and chemical water quality impacts, arising from a variety of sources including industrialization and urban development, agricultural runoff, mining, and timber harvest, are also prevalent throughout much of the subspecies' range. Channelization is also common in many agricultural and urban areas.

Regional or site-specific threats can compound the primary, range-wide impacts. Regional or site-specific threats include additional habitat destruction caused by recreational boating and in-stream sand and gravel mining. Others consist of inadequately regulated, unregulated, or illegal harvest and sale of hellbenders, as well as disease and predation caused by non-native fish species. Ozark hellbenders also have naturally low within-population genetic diversity. Extant populations are often small, and because of barriers such as dams and polluted stream reaches, geographically isolated. These factors make individual populations susceptible to catastrophic events, and make recolonization following these events unlikely. Population isolation, coupled with an apparent lack of recruitment in much of the range, indicates that current populations of the Ozark hellbender may not be sustainable.

Imminence: The majority of the threats to the Ozark hellbender are imminent. Many are historical and ongoing, such as impoundments, channelization, sedimentation, chemical water quality impairments, and overutilization. The threats have resulted in a decline in the subspecies throughout its range. It is absent from much of its historical range, and many extant populations are exhibiting population declines and poor recruitment. Future expansion of human populations will increase the likelihood that many of these habitat-related threats will continue to impact remaining populations of this species.

Yes Have you promptly reviewed all of the information received regarding the species for the purpose of determining whether emergency listing is needed?

Is Emergency Listing Warranted? Emergency listing is not warranted at this time. Although the magnitude and immediacy of threats to Ozark hellbenders are high, expected losses to Ozark hellbender populations during the normal listing process would not risk the continued existence of the entire species or loss of significant recovery potential.

DESCRIPTION OF MONITORING:

The Arkansas Game and Fish Commission (AGFC) recently received funding to initiate a long term monitoring effort of Ozark hellbenders. This work will be coordinated and conducted by the AGFC herpetologist and will focus on the Eleven Point River population, as this is the only extant population in Arkansas with sufficient numbers to be able to detect any significant changes over time. Monitoring will be conducted on an annual basis and will encompass a reach of river known to harbor hellbenders, as well as expand survey efforts into areas that have not been systematically searched.

The first annual MDC hellbender survey week was held from August 12 through August 15, 2003 on the Jacks Fork and Current River. The main purpose of this survey was to determine possible long-term monitoring sites as well as assess hellbender status in selected stretches of these rivers.
During 2004, survey efforts focused on U.S. Forest Service property in areas that have received little or no survey attention. This included the upper reaches of the Eleven Point River (above Greer's Spring), Upper reaches of North Fork (Topaz Spring to twin bridges), and a section of the upper Black River (J. Briggler, pers. comm.). Surveys of these areas continued in 2005.

The Ozark hellbender working group has developed standardized, long-term monitoring protocols for the entire range of the Ozark hellbender. The monitoring protocol will be piloted on a representative river or river segments. An additional objective of this protocol is to develop and maintain a standardized pit tagging database for Ozark hellbenders.

COORDINATION WITH STATES

Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment: Missouri and Arkansas

Indicate which State(s) did not provide any information or comments: NA – full range of the species covered by Missouri and Arkansas (above)

LITERATURE CITED

Allan, J. D. 1995. Stream ecology: structure and function of running waters. Chapman and Hall, New York, NY.

Allan, J. D. and A. S. Flecker. 1993. Biodiversity conservation in running waters. Bioscience 43:32-43.

Bishop, S.C. 1941. Salamanders of New York. New York State Museum Bulletin 324:1-365.

Blaustein, A. R. and D. B. Wake. 1990. Declining amphibian populations: a global phenomenon? Trends in Ecology and Evolution 5:203-204.

Bothner, R.C., and J.A. Gottlieb. 1991. A study of the New York State populations of the hellbender, *Cryptobranchus alleganiensis alleganiensis.* Proceedings of the Rochester Academy of Science 17(1):41-54.

Box, J. B. and J. Mossa. 1999. Sediment, land use, and freshwater mussels: prospects and problems. Journal of the North American Benthological Society 18:99-117.

Bradford, D.F. 1989. Allopatric distribution of native frogs and introduced fishes in high Sierra Nevada lakes of California: implications of the negative effects of fish introductions. Copeia 1989: 774-778.

Brodie, E.D., Jr. 1971. Two more toxic salamanders, *Ambystoma maculatum* and *Cryptobranchus alleganiensis*. Herpetological Review 3:8.

Bruce, R.C. 1977. *Cryptobranchus alleganiensis alleganiensis* hellbender. Pp. 316-317 In: J.E. Cooper, S.S. Robinson, and J.B. Funderburg (eds.), *Endangered and Threatened Plants and Animals of North Carolina*, N.C. State Mus. Nat. Hist., Raleigh, N.C.

Bury, R.B., C.K. Dodd, Jr., and G.M. Fellers. 1980. Conservation of the Amphibia of the United States: a review. Resource Publication 134, U.S. Fish and Wildlife Service, Washington, D.C., 34p.

Cash,W.B. 1996. Population status of the hellbender, *Cryptobranchus alleganiensis*, in Bear Creek, Tishomingo County, Mississippi.

Cilburn, W. 1991. Status of *Cryptobranchus alleganiensis* in Mississippi. Final Report to the Mississippi Commission on Wildlife Conservation, Mississippi Natural Heritage Program.

Colborn, T., F.S. vom Saal, and A.M. Soto. 1993. Developmental effects of endocrine-disrupting chemicals in wildlife and humans. Environmental Health Perspectives 101:378-384.

Collins, J. T. 1991. Viewpoint: a new taxonomic arrangement for some North American amphibians and reptiles. Herpetological Review 22:42-43.

Collins, J. T. 1997. Standard Common and Current Scientific Names for North American Amphibians and Reptiles: Fourth Edition Updated, Society for the Study of Amphibians and Reptiles, Herpetological Circular 25:1-40.

Collins, J.T., and T.W. Taggart. 2002. Standard Common and Current Scientific Names for North American Amphibians, Turtles, Reptiles & Crocodilians: Fifth Edition. Publication of the Center for North American Herpetology, Lawrence, KS. iv + 44 pp.

Conant, R.A. 1975. A field guide to reptiles and amphibians of eastern and central North America, second edition. Pp240-241, PI 37.

Congdon, J.D., A.E. Dunham, and R.C. Van Loben Sels. 1993. Delayed sexual maturity and demographics of Blanding's Turtles (*Emydoidea blandingii*): implications for conservation and management of long-lived organisms. Conservation Biology 7:826-833.

Cope, E.D. 1889. The batrachia of North America. U.S. National Museum Bulletin 34:1-525.

Danch, J. 1996. The hellbender. Reptiles 4:48-59.

Davis, J.V. and J.M. Richards. 2002. Assessment of possible sources of microbiological contamination and water-quality characteristics of the Jacks Fork, Ozark National Scenic Riverways, Missouri – Phase II.)

DNR- Maryland web-site. 2000a. Rainbow trout *Oncorhynchus mykiss*. http://www.dnr.state.md.us/fisheries/education/trout/rainbowtrout.html. Accessed on 8 September 2003.

DNR- Maryland web-site. 2000b. Brown trout *Salmo trutto*. http://www.dnr.state.md.us/fisheries/education/trout/browntrout.html. Accessed on 8 September 2003.

Dodd, Jr., C.K. 1997. Imperiled amphibians: a historical perspective. In: G.W. Benz and D.E. Collins (Eds.). *Aquatic Fauna in Peril: The Southeastern Perspective*. Southeast Aquatic Research Institute, Lenz Design and Communications, Deatur, Georgia, Special Publication 1, pp. 165-200.

Dundee, H. A. 1971. Cryptobranchus, and C. alleganiensis. Catalogue of American amphibians and reptiles: 101.1-101.4.

Dundee, H. A. and D. S. Dundee. 1965. Observations on the systematics and ecology of Cryptobranchus from the Ozark plateaus of Missouri and Arkansas. Copeia 1965:369-370.

Dunham, J.B., D.S. Pilliod, and M.K. Young. 2004. Assessing the consequences of nonnative trout in headwater ecosystems in western North America. Fisheries 29(6):18-26.

Ellner, S. and N.G. Hairston, Jr. 1994. Role of overlapping generations in maintaining genetic variation in a fluctuating environment. American Naturalist 143:403-417.

Federal Interagency Stream Restoration Working Group. 1998. Stream corridor restoration: principles processes, and practices. www.usda.gov/stream_restoration

Ferguson, D.E. 1961. The herptofauna of Tishomingo County, Mississippi with comments on its zoogeographic affinities. Copeia 1961:391-396.

Firschein, I. L. 1951. The range of Cryptobranchus bishopi and remarks on the distribution of the genus Cryptobranchus. The American Midland Naturalist 45:455-459.

Fobes, T. M. and R. F. Wilkinson. 1995. Summer, diurnal habitat analysis of the Ozark hellbender, Cryptobranchus alleganiensis bishopi, in Missouri. Final Report, Southwest Missouri State University.

Frank, W.C. and W.W. Dunlap. 1999. Colonization of high-elevation lakes by long-toed salamanders (*Ambystoma macrodactylum*) after the extinction of local trout populations. Canadian Journal of Zoology 77: 1759-1767.

Frissell, C. A. 1997. Ecological Principles. Pp 96-115 In: J. E. Williams, C. A. Wood, and M. P. Dombeck, eds. Watershed restoration: principles and practices. American Fisheries Society, Bethesda, MD.

Gates, J.E. 1983. The distribution and status of the hellbender (*Cryptobranchus alleganiensis*) in Maryland: I. The distribution and status of Cryptobranchus alleganiensis in Maryland. II. Movement patterns of translocated *Cryptobranchus alleganiensis* in a Maryland stream. Maryland Wildlife Administration.

Gates, J.E., C.H. Hocutt, J.R. Stauffer, Jr. 1984. The status of the hellbender (*Cryptobranchus* *alleganiensis*) in Maryland. Pp. 329-335 In: A.W. Norden, D.C. Forester, and G.H. Fenwick (eds.), *Threatened and Endangered Plants and Animals of Maryland*. Maryland Natural History Program, Special Publication 84-I, Annapolis, MD.

Gates, J.E., C.H. Hocutt, J.R. Stauffer, Jr., and G.J. Taylor. 1985. The distribution and status of *Cryptobranchus alleganiensis* in Maryland. Herpetological Review 16:17-18.

Gillespie, G.R. 2001. The role of introduced trout in the decline of the spotted tree frog (*Litoria spenceri*) in south-eastern Australia. Biological Conservation 100: 187-198.

Gilpin, M.E. and M.E. Soulé. 1986. Minimum viable populations: the processes of species extinction. Pages 13-34 in *Conservation Biology: The Science of Scarcity and Diversity*, M.E. Soulé (ed.). Sinaur Associates, Sunderland, Mass.

Green, N.B. 1933. *Cryptobranchus alleganiensis* in West Virginia. Proc. W. Va. Acad. Sci. 7: 28-30.

Green, N.B. 1934. *Cryptobranchus alleganiensis* in West Virginia. Proc. W. Va. Acad. Sci. 7: 28-30.

Green, N.B. 1935. Further notes on the food habits of the water dog, *Cryptobranchus alleganiensis* (Daudin). Proceedings of the Academy of Science 9:36.

Green, N.B. and T.K. Pauley. 1987. *Amphibians and Reptiles in West Virginia*. University of Pittsburgh Press. Pittsburgh, Pa.

Grobman, A. B. 1943. Notes on salamanders with the description of a new species of Cryptobranchus. Occasional papers of the Museum of Zoology, University of Michigan Press, Ann Arbor, MI.

Guillette, L.J., Jr., T.S. Gross, G.R. Masson, J.M. Matter, H.F. Percival, and A.R. Woodward. 1994. Developmental abnormalities of the gonad and abnormal sex hormone concentrations in juvenile alligators from contaminated and control lakes in Florida. Environmental Health Perspectives 102:680-688.

Guimond, R.W. 1970. Aerial and aquatic respiration in four species of paedomorphic salamanders: *Amphiuma means means*, *Cryptobranchus alleganiensis alleganiensis*, *Necturus maculosus maculosus*, and *Siren lacertina*. PhD Dissertation. University of Rhode Island.

Hall, H.H. and H.M. Smith. 1947. Selected records of reptiles and amphibians from southeastern Kansas. Transactions of the Kansas Academy of Science 49(4):447-454.

Harlan, R.A. and R.F. Wilkinson. 1981. The effects of progressive hypoxia and rocking activity on blood oxygen tension for hellbenders, *Cryptobranchus alleganiensis*. Journal of

Herpetology 15(4):383-388.

Harvey, E.J. 1980. Ground water in the Springfield-Salem Plateaus of southern Missouri and northern Arkansas. U.S. Geological Survey, Water Resources Investigations 80-101. 66pp.

Hay, O.P. 1892. The batrachians and reptiles of the state of Indiana. Indiana Department of Geology and Natural Resources Annual Report 17:409-602.

Hillis, R.E. and E.D. Bellis. 1971. Some aspects of the ecology of the hellbender *Cryptobranchus alleganiensis alleganiensis*, in a Pennsylvania stream. Journal of Herpetology 5:121-126.

Huckabee, J.H., C.P. Goodyear, and R.D. Jones. 1975. Acid rock in the Great Smokies: unanticipated impact on aquatic biota of road construction in regions of sulfide mineralization. Transactions of the American Fisheries Society 104(4):677-684.

Humphries, W.J. 1999. Ecology and population demography of the hellbender, *Cryptobranchus alleganiensis*, in West Virginia. M.S. Thesis, Marshall University, Huntington, WV.

Jensen, J.B. 1999. Hellbender *Cryptobranchus alleganiensis*. *In* Protected animals of Georgia. Nongame-Endangered Wildlife Program, Georgia Department of Natural Resources, Social Circle, GA. Pp. 98-99.

Johnson, T. R. 1987. The amphibians and reptiles of Missouri. Missouri Department of Conservation, Jefferson City.

Kern, W.H. 1984. The hellbender, *C. alleganiensis* in Indiana. M.A. thesis, Indiana State University. 48 pp.

Kern, W.H., Jr. 1986b. The range of the hellbender, *Cryptobranchus alleganiensis alleganiensis*, in Indiana. Proceedings of the Indiana Academy of Science 95:520-521.

Kiesecker, J.M., A.R. Blaustein, and L.K. Belden. 2001. Complex causes of amphibian population declines. Nature 410:681-684.

King, W. 1939 A survey of the herpetology of Great Smoky Mountain National Park. American Midland Naturalist 21:531-582.

Krecker, F.H. 1916. *Filaria cingula* parasitic in the skin of *Cryptobranchus alleganiensis*. Parasitology 2:74-79.

Lande, R. 1988. Genetics and demography in biological conservation. Science 241:1455-1461

LaClaire, L. V. 1993. Status review of Ozark hellbender (Cryptobranchus bishopi). U.S. Fish and Wildlife Service status review. Jackson, Mississippi.

Mayasich, J., D. Grandmaison, and C. Phillips. 2003. Eastern hellbender status assessment report. Report to the US Fish and Wildlife Service, NRRI/TR-2003/09. 66 pp.

McMullen, D.B. and R.L. Roudabush. 1936. A new species of trematode, *Cercorchis cryptobranchi*, from *Cryptobranchus alleganiensis*. J. Parasitol. 22:516-517.

MDC web-site. 2003. Watershed, Eleven Point River, Biotic Community Chapter, Table BC07. http://www.conservation.state.mo.us/fish/watershed/elevenpt/biotic/090bct07.htm. Accessed on 26 August 2003.

MDC web-site. 2002. Missouri fish and wildlife information system. http://www.conservation.state.mo.us/cgi-bin/mofwis.htm. Accessed on 26 August 2003.

Merkle, D. A., S. I. Guttman, and M. A. Nickerson. 1977. Genetic uniformity throughout the range of the hellbender, Cryptobranchus alleganiensis. Copeia 1977:549-553.

Missouri Department of Conservation. 2003. A plan for Missouri trout fishing. Missouri Department of Conservation publication.

Neves, R. J., A. E. Bogan, J. D. Williams, S. A. Ahlstedt, and P. W. Hartfield. 1997. Status of aquatic mollusks in the southeastern United States: a downward spiral of diversity. Pp. 43-85 *in* G. W. Benz and D. E. Collins, eds. Aquatic fauna in peril: the southeastern perspective. Southeast Aquatic Research Institute, Decatur, GA.

Nevo, E. 1978. Genetic variation in natural populations: patterns and theory. Theoretical Population Biology 13:121-177.

Nickerson, M. A. and C. E. Mays. 1973a. The hellbenders: North American giant salamanders. Milwaukee Public Museum Publications in Biology and Geology 1:1-106.

Nickerson, M. A. and C. E. Mays. 1973b. A study of the Ozark hellbender Cryptobranchus alleganiensis bishopi. Ecology 54:1164-1165.

Nickerson, M.A., K.L. Krysko, and R.D. Owen. 2002. Ecological status of the hellbender (*Cryptobranchus alleganiensis*) and the mudpuppy (*Necturus maculosus*) salamanders in the Great Smoky Mountains National Park. J. North Carolina Acad. Sci. 118:27-34.

Nigrelli, R.F. 1954. Some longevity records of vertebrates. New York Academy of Sciences 16(6):296-299.

Noeske, T. A. and M. A. Nickerson. 1979. Diel activity rhythms in the hellbender, Cryptobranchus alleganiensis (Caudata: Cryptobranchidae). Copeia 1979:92-95.

Noss, R.F. and A.Y. Cooperrider. 1994. *Saving Nature's Legacy: Protecting and Restoring*

Biodiversity. Island Press, Washington, D.C.

Peterson, C.L. 1987. Movement and catchability of the hellbender, *Cryptobranchus alleganiensis.* Journal of Herpetology 21(3):197-204.

Petersen, J.C., Adamski, J.C., Bell, R. W., Davis, J.V., Femmer, S.R., Freiwald, D.A., and Joseph, R.L. 1998. Water quality in the Ozark plateaus: Arkansas, Kansas, Missouri, and Oklahoma. U.S. Geological Survey Circular 1158, on line at URL: http://water.usgs.gov/pubs/circ1158, updated April 3, 1998

Peterson, C. L., D. E. Metter, and B. T. Miller. 1988. Demography of the hellbender Cryptobranchus alleganiensis in the Ozarks. American Midland Naturalist 119:291-303.

Peterson, C. L. and R. F. Wilkinson, Jr. 1996. Home range size of the hellbender (Cryptobranchus alleganiensis) in Missouri. Herpetological Review 27:127.

Peterson, C. L., R. F. Wilkinson, Jr., M. S. Topping, and D. E. Metter. 1983. Age and growth of the Ozark hellbender (Cryptobranchus alleganiensis bishopi). Copeia 1983:225-231.

Petranka, J.W. 1998. Salamanders of the United States and Canada. Smithsonian Institution.

Pfingsten, R.A. 1988. The status and distribution of the hellbender, *Cryptobranchus alleganiensis*, in Ohio. Unpublished report to the Ohio Department of Natural Resources. 25 pp.

Pfingsten, R.A. 1989. The status and distribution of the hellbender, *Cryptobranchus alleganiensis*, in Ohio. Ohio Journal of Science 89(2):3.

Pfingsten, R.A. 1990. The status and distribution of the hellbender, *Cryptobranchus alleganiensis* in Ohio. Herpetological Review 21(3):48-51.

Pfingsten, R.A. and F.L. Downs, eds. 1989. Salamanders of Ohio. Ohio Biol. Surv. New Series Vol. 7 No. 2.

Pounds, J.A. 2001. Climate change and amphibian declines. Nature 410:639-640.

Prosen, E., B. Wheeler, R. Wilkinson, A. Mathis, and B. Greene. 1998. Missouri hellbender survey: a progress report. Unpublished report for Southwest Missouri State University.

Routman, E. 1993. Mitochondrial DNA variation in Cryptobranchus alleganiensis, a salamander with extremely low allozyme diversity. Copeia 1993:407-416.

Saccheri, I. M. Kuussaari, M. Kankare, P. Vikman, W. Fortelius, and I. Hanski. 1998. Inbreeding and extinction in a butterfly metapopulation. Nature 392:491-492.

Schmidt, K. P. 1953. A checklist of North American amphibians and reptiles. 6th edition. American Society of Ichthyologists and Herpetologists.

Shaffer, H. B. and F. Breden. 1989. The relationship between allozyme variation and life history: non-transforming salamanders are less variable. Copeia 1989:1016-1023.

Smith, B.G. 1907. The life history and habits of *Cryptobranchus alleganiensis*. Biological Bulletin 13: 5-39.

Smith, P.W. and S.A. Minton, Jr. 1957. A distributional summary of the herpetofauna of Indiana and Illinois. The American Midland Naturalist 58:341-351.

Smith, H.M. and A.J. Kohler. 1977. A survey of the herpetological introductions in the United States and Canada. Transactions of the Kansas Academy of Science 80(1-2):1-24.

Solis, M.E., and Y. Huang. 2005a. Hematology and serum chemistry of Ozark and Eastern Hellbenders (*Cryptobranchus alleganiensis bishopi*). MDC Final Report. Jefferson City, MO.

Solis, M.E. and Y. Huang. 2005b. Reproductive hormones in the breeding season of Ozark hellbenders (*Cryptobranchus alleganiensis bishopi).* MDC Final Report. Jefferson City, MO.

Solis, M.E., C. Liu, P. Nam, D Niyogi, and Y. Huang. 2005c. Chemical and nutrient assessment in the North Fork of the White River and the Eleven Point River, Missouri and possible impact on Ozark Hellbenders (*Cryptobranchus alleganiensis bishopi) population.* MDC Final Report. Jefferson City, MO.

Swanson, P.L. 1948. Notes on the amphibians and reptiles of Venango County, Pennsylvania. The American Midland Naturalist 40:362-371.

Taber, C.A., R.F. Wilkinson, Jr., and M.S. Topping. 1975. Age and growth of hellbenders in the Niangua River, Missouri. Copeia 1975:633-639.

Topping, M.S and C.A. Ingersol 1981 Fecundity in the hellbender, Cryptobranchus alleganiensis. Copeia 1981:873-876.

Trauth, S. E., J. D. Wilhide, and P. Daniel. 1992. Status of the Ozark hellbender, Cryptobranchus bishopi, (Urodela: Cryptobranchidae), in the Spring River, Fulton County, Arkansas. Proceedings of the Arkansas Academy of Science 46:83-86.

Ultsch, G.R. and J.T. Duke. 1990. Gas exchange and habitat selection in the aquatic salamanders *Necturus maculosus* and *Cryptobranchus alleganiensis*. Oecologia 83(2):250-258.

Unger, S.D. 2003. Sperm production and larval development in hellbenders (*Cryptobranchus alleganiensis alleganiensis* and *C. A. bishopi*): a comparison of declining and stable populations. M. S. Thesis. Southwest Missouri State University. Springfield.

Wagner, B. K., H. Kucuktas, and R. Shopen. 1999. Hellbender genetics project final report: evaluation of the genetic status of the Ozark hellbender population in the Spring River, Arkansas. Arkansas Game and Fish Commission, Little Rock, AR.

Welsh, H.H. and L.M. Ollivier. 1998. Stream amphibians as indicators of ecosystem stress: a case study from California's redwoods. Ecological Applications 8:1118-1132.

Wheeler, B.A., E. Prosen, A. Mathis, and R.F. Wilkinson. 2003. Population declines of a long-lived salamander: a 20+ year study of hellbenders, *Cryptobranchus alleganiensis*. Biological Conservation 109:151-156.

Wheeler, B. A. 1999. Status of the Ozark hellbender (Cryptobranchus alleganiensis bishopi): a long-term assessment. M.S. Thesis. Southwest Missouri State University, Springfield, MO.

Wheeler, B. A., E. Prosen, A. Mathis, and R. Wilkinson. 1999. Missouri hellbender status survey: final report. Missouri Department of Conservation, Springfield, MO.

Wheeler, B. A. and S. E. Trauth. 2002a. Distribution survey of the Ozark hellbender, *Cryptobranchus alleganiensis bishopi* in Arkansas: final report. Arkansas Game and Fish Commission, Little Rock, AR. 20pp.

Wheeler, B. A. and S. E. Trauth. 2002b. Distributional survey of the Ozark hellbender, *Cryptobranchus alleganiensis bishopi*: final report for field season 2001. U.S. Fish and Wildlife Service, Conway, AR. 22pp.

Williams, R. D., J. E. Gates, C. H. Hocutt, and G. J. Taylor. 1981. The hellbender: a non-game species in need of management. Wildlife Society Bulletin 9:94-100.

Wyman, R.L. 1990. What's happening to the amphibians? Conservation Biology 4:350-352.

Ziehmer, B. and T. Johnson. 1992. Status of the Ozark hellbender in Missouri. Missouri Department of Conservation, Jefferson City, MO.

Zug, G. R. 1993. Herpetology: an introductory biology of amphibians and reptiles. Academic Press, San Diego, CA.

APPROVAL/CONCURRENCE: Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve: /s/ Charlie Wooley — 3/1/2006

Acting Regional Director, Fish and Wildlife Service — Date

Concur: ______________________ — August 23, 2006

Director, Fish and Wildlife Service — Date

Do not concur: ______________________

Director, Fish and Wildlife Service — Date

Director's Remarks:

Date of annual review:
Conducted by:

Comments: